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Original research article

Energetic voices on social media? Strategic Niche Management and Finnish Facebook debate on biogas and heat pumps

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ABSTRACT

Strategic niches are protected spaces for emerging technologies, where expectations are articulated, social networks built, and learning occurs. Although Strategic Niche Management (SNM) can be done in a directed, strategic manner, more diffuse, loosely connected and self-organizing niches also exist. We explore such niches in a particular setting: a social media discussion forum – a Facebook group – set up for an open discussion on the reform of national-level energy policy in Finland. We focus on discussions related to two renewable energy technologies: biogas and ground-source heat pumps. We conduct Social Network Analysis and quantitative as well as qualitative content analysis of the social media material to ask what kind of SNM happens in these discussions. Our results indicate that the discussion networks may be conducive for wide engagement and incorporation of new ideas, while also containing sub-groups that may foster learning. However, the discussions are highly centralized around a few active discussants and focused on the present-day situation, drawing from specific local and national experiences and technical details, despite the original aim of the group to induce forward-looking debates on energy policy. The articulation of future expectations is not a predominant feature of the discussions related to these two technologies. Still, the quantitative content analysis reveals extensive agreement in their framing as sustainable future energy solutions, while the qualitative analysis also points to critical debates that may support learning and further development of shared expectations.

1. Introduction

Climate and sustainability concerns call for a radical reorganization of energy systems. Technological development alone is likely to be insufficient to meet the challenge – policies and public debates initiating and supporting the changes are needed. In particular, various online applications and social media platforms are increasingly important as arenas for communication and knowledge sharing in climate and energy debates [1–5]. Online communication can both accelerate and hinder energy transitions, for example, by allowing developers and users of clean technologies to participate in media content creation and distribution [6], exposing people to diverse viewpoints and new knowledge, or limiting exposure through 'echo chambers' [7], omitting relevant or highlighting irrelevant views or risks [8], mobilizing campaigns and social movements [1,4], amplifying the effects of place-based initiatives [4], and influencing behavioural change [9,10]. Competing visions of just energy transitions are scrutinized on social media, swaying public attention and ultimately influencing politics and policies [5].

Finland provides an interesting example to study energy transition. It is already performing relatively well in terms of renewable energy: the share of renewable energy of total energy consumption has increased from 18% in 1990 to 37% in 2017 [11]. According to recent estimates, Finland could achieve carbon neutrality around 2040 [12] or already in 2035 assuming that a set of strong policy measures is efficiently and urgently implemented [13]. An energy transition has been called for by various stakeholders and emphasized in public debates [14,15] and also acknowledged in the national energy and climate strategy [16] and in the current government programme [17]. The per capita energy consumption in Finland exceeds the level of energy consumption of most high-income countries [18]. Moreover, the most important source of renewable energy in the country is wood, which is increasingly questioned due to trade-offs related to the role of forests as a carbon sink as well as other environmental impacts [19,20].

The means to achieve an energy transition in Finland are subject to an intense public debate but one that is largely focused on the

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sustainability of wood energy [19]. Attention to a diverse and distributed energy mix, drawing from various renewables, has been called for [15]. In this study, we focus on debates concerning the role of niche-level technologies that may complement the renewable energy portfolio while promising additional benefits for job creation, rural livelihoods, energy efficiency, waste management and circular economy: biogas and ground-source heat pumps.

We apply a Strategic Niche Management (SNM) approach, often used to study the co-evolution of niche technologies, user practices, and regulatory structures within socio-technical transitions [21]. The key processes in Strategic Niche Management are the building of social networks; the articulation of shared expectations and visions; and learning processes over a variety of technical, market, infrastructure, regulatory and social issues [21,22]. The flow of information and communication is central for these processes [23]. We focus on a particular setting in which communication and public debates increasingly take place but has been little explored as a context for SNM: the social media.

We investigate the niches of biogas and ground-source heat pumps using discussions in a Finnish Facebook group called 'New Energy Policy' ('Uusi energiapolitiikka', in Finnish), dedicated to promote energy transition, as our data. Both technologies are fairly mature, but have a small market share, with stakeholders trying to figure out their place in the energy system. The Facebook group offers a unique window into these niches.

Through a SNM lens, we aim to answer the following research questions: what kind of social networks are formed around discussions on biogas and ground-source heat pumps? How do the network structures support the exchange of ideas, experiences and learning? What kind of expectations and visions are articulated regarding the two niche technologies and their roles in the future energy regimes? What is the level of alignment of those expectations and what kind of divergent viewpoints can be observed? An interesting backdrop for the analysis is that the New Energy Policy group was specifically set up to stimulate debates related to a perceived need to reform national-level energy policy in Finland. Thus we also ask whether the discussions on biogas and ground-source heat pumps match the original goal of the group founders to motivate future-orientated debates on renewable energy solutions.

The analysis describes the features of self-organizing Strategic Niche Management on an open online forum. The study aims to make novel contributions to social scientific research on energy systems by (1) applying the Strategic Niche Management approach to study renewable energy debates and framing in a new context, a social media platform; (2) using a rigorous Social Network Analysis method to study the social networking aspect of SNM in relation to diverse and open discussion networks, thus adding to the insights of previous studies focusing on smaller offline networks [23–26]; and (3) helping to fill a gap in the SNM literature regarding the content of expectations and visions related to niche technologies [22], through quantitative and qualitative analysis of the social media material.

2. Theoretical background

2.1. Strategic Niche Management (SNM)

Strategic niches are "protected spaces that allow nurturing and experimentation with the co-evolution of technology, user practices, and regulatory structures" [21, p. 538]. In theory, they support new technological pathways capable of penetrating the prevailing socio-technical regimes, destabilizing or replacing unsustainable technologies [22, p. 236]. Importantly, the niche does not refer to local or minor projects – while these form the basis of the niche, there needs to be a "global niche", a community level where shared rules are enacted and framed that feeds into the individual small projects (and in turn learns from those experiences) [21].

Strategic Niche Management research has emerged over the past two decades to understand these niches and their role in socio-technical transitions [22]. The theoretical approach has also been used with a specific strategy in mind, by actors who are trying to enact change and use niche management as a policy tool [27]. However, policy relevance in the sense of setting up a management system is not necessarily the essence of the approach: niches can emerge organically through collective action, and can be steered by a range of actors endogenously [21]. In the academic literature, SNM has been applied as an analytical tool [22], and shedding light on the key processes happening in a niche through analysis is valuable for decision-makers, even in the absence of a "manager".

The key processes of SNM are social networking, articulation and convergence of expectations and visions, and mutual learning among niche actors [21]. Since networks function as conduits for the spread of ideas, practices and beliefs, networking may be considered as underlying the other two functions [23]. The building of social networks is important to create a constituency behind a technology, facilitate interactions between relevant stakeholders, and provide the necessary resources (money, people, and expertise). Social networks are likely to contribute to niche development if they are broad and diverse, i.e. multiple kinds of stakeholders are included to facilitate the articulation of multiple views and voices. Participants in the networks should also be able to mobilize commitment and resources within their own organizations and networks [21].

Information and collaboration networks are central for the emergence and diffusion of innovations [28,29]. Wide and diverse networks enable access to novel information, by connecting actors that would not otherwise be connected through so-called weak ties [30]. Relatively loose, open networks with many connections may generate more new ideas than small, closely-knit networks. However, it has also been noted that close interaction between actors by means of intensive communication enables the sharing of important tacit, informal and uncodified elements in the new knowledge [23]. Weak ties may work well as conduits of information but less so for persuasion and behaviour change, because they contain less trust and reinforcement [29]. The composition and effective width of the network may vary according to the different stages in the innovation cycle, e.g. ideas may be best conceived through broad and loose networks, the invention phase may involve a more closed circle of collaborators, and the commercialization and scaling up phases may benefit from the incorporation of different types of actors with market and policy knowledge in broader networks [31].

Expectations include all kinds of collective and individual visions, scenarios and other depictions of the future that draw (positive or negative) attention to different options, helping to direct and legitimize interest and investment in potential solutions [32]. Changes in technological trajectories depend on changes in the contents of the visions [33].The convergence and alignment of expectations refers to the importance of developing a common core view about where the participating actors are going with each other and with the technology [23]. Expectations are most powerful when they are shared by more actors, more specific (if expectations are too general they do not give guidance), and the content of expectations is substantiated by evidence [21]. Hence the actors' strategies, expectations, beliefs, practices, outlooks, perceptions and views must go in the same direction and become more specific and consistent [23].

Learning includes articulating the barriers that the niche faces and how they can be dealt with [34]. Networks can affect learning in two ways: exposure to diverse ideas in wide networks supports broad learning, but too much diversity can prevent accumulative learning [22]. Learning processes may concern multiple dimensions of niche technologies, such as technical aspects and design specifications, market and user preferences, cultural and symbolic meaning, infrastructure and maintenance networks, industry and production networks, regulations and government policy, as well as societal and

environmental effects [21].

Though a linear SNM process of first defining the shared expectations and visions, then networking with the right actors for learning and experimentation, has been presented [25], in this paper we adopt the view that the internal niche processes are closely linked and form an iterative cycle of activities in the niche [24, p. 614]. Hence, they are analysed and presented in parallel with each other.

2.2. Social media as an arena of SNM

Open social media platforms can be considered as hybrid virtual communities [35]. Virtual communities are informal online groups that share common practices and rules. They are hybrid in the sense that they encompass the sphere of professional expertise, but also that of lay-users and enthusiasts. It is therefore expected that open social media platforms can facilitate SNM by helping to widen the constituencies of niche technologies and to bridge the knowledge of niche professionals, users in different roles (producer, consumer and intermediary [36]) and other actors, such as market and policy experts, in the articulation of shared expectations and visions in processes of mutual learning.

By default, social media – particularly popular applications like Facebook – serves social networking of the involved actors. Social network research on online communities has generally confirmed that connections maintained online are as real as offline ties, entailing trust and disclosure and supporting relations of work, advice and socializing [37]. Importantly, internet platforms can attract levels of attention and engagement of wholly different magnitudes compared to offline networking between e.g. energy projects and community energy groups [36]. Though specialized user-run internet forums for niche energy technologies exist [cf. 36], it is especially the popular social media platforms that anyone can join that have the potential to significantly broaden the communication networks for niche technologies. Social media can create new roles for actors that mediate between development and use of technologies, where these intermediaries are involved in configuring technologies and systems, facilitating their uptake and brokering between actors and systems [36]. They may also offer an opportunity to reach out to regime actors, such as politicians that are pressurized to be “visible” i.e. to participate in discussions on social media, help change their perceptions and create cracks in the regime [22] to accelerate the diffusion of niche technologies.

Social media platforms can provide arenas for deliberation to form and align shared expectations on niche technologies, to deepen them through mutual learning, and to substantiate them with evidence. A key condition for successful SNM is the possibility for continuous evaluation and improvement though broad stakeholder processes, including users [27]. Social media can also be used to re-contextualize technologies to local and national specifics [36]. How the niche technologies are framed in these processes influences opinion formation and the shaping up of shared expectations and visions. Framing refers to how people construct meaning and make sense of the information they encounter, and which aspects of an issue are emphasized when that information is further communicated [38]. In the SNM literature, there has been a notable shortage of attention to the component of expectations and visions, and an overemphasis of agency and structure at the expense of meaning [22]. Studying the framing of niche technologies in social media debates can contribute to filling that gap.

Though social media platforms as arenas to exchange ideas and information can support the SNM processes of networking, learning and the formation and alignment of expectations, they may also have characteristics that filter the spread of ideas and content. Attention has been paid to how social media algorithms and users’ practices (past attention to similar posts) limit user exposure to diverse content [39,40]. It has been studied how the curation of news feeds by Facebook undermines its role as a forum for public deliberation, though researchers affiliated with Facebook found the effect to be modest compared to people's own choices to interact with the content [39]. However, more independent studies on the social organizing effects of social media algorithms have been called for [40]. Other potential pitfalls related to using social media material to study energy perceptions include data contamination by fake accounts and spam, and uncertain representation of the general population [5].

It has also been observed that user-run energy internet forums do not focus on critical discourse, but the discussions rather revolve around specific economic and technological issues [36]. It is therefore intriguing to investigate how a social media platform specifically set up to mobilize critical debates on energy policy reform works for SNM, considering the tendency of niche-technology discussants to focus on more pragmatic technical and economic aspects.

While popular in social media research, a small number of studies applying SNM and similar innovation network approaches have used a Social Network Analysis method, instead of just using networks as a conceptual framework. Networks analysed in this way include the Japtropha biodiesel SNM of Caniëls & Romijn [23], the bio-refinery niche in Apulia, Italy of Lopolito et al. [25], the Dutch agricultural niche of Hermans et al. [24], and the emerging technologies innovation networks of van der Valk et al. [26]. The networks in these papers consist of a small number of persons or organizations (10–100) and vary in their definition on how these actors are linked. Our study complements these studies by looking at broader and more open communication networks established on social media. Network metrics do not make sense in isolation, so we use comparison with these studies as a baseline for interpretation.

3. Material and methods

3.1. Material

We analyse the niches of biogas and ground-source heat pumps in Finland by making the key niche processes visible through the window of social media discussions. The material was retrieved from a Finnish discussion group on Facebook named ‘New Energy Policy’ (‘Uusi energiapolitiikka’ in Finnish). The group is public but closed, meaning that anyone can find the group on Facebook, see who is in it and read the posts, but in order to participate in the discussions i.e. to post content, one's request for membership has to be approved by an existing member. The group was established in November 2014 and it has over 6100 members (status 31st May 2019). The group was established as part of a campaign with the same name to promote energy policy reform in Finland with the advent of the parliamentary elections in 2015. The campaign stemmed from a statement by a group of university professors arguing for a less CO_2-intensive energy system [15] and was funded by several businesses and interest groups mainly from the renewable energy sector[1]. While the campaign is finished, discussions on the Facebook group remain active and cover renewable energy issues broadly.

We used the Facebook Graph API via the Rfacebook package interface [41] to gather material from the group. The main corpus built consisted of all posts and comments posted on the group between 23rd November 2014 and 13rd February 2017. From the main corpus, discussion threads including the opening post and the subsequent comments were selected for analysis based on the presence of one or several of the search terms “biogas*” (in Finnish: “biokaasu*”), “geotherm*” or “heat pump*” (in Finnish: “maaläm* or lämpöpum*”)[2] in the opening post. The R scripts used for the collection and handling of the data are

[1] http://www.energiapolitiikka.fi/, in Finnish

[2] Because of the inflections of words in the Finnish language, the use of wildcards with the search terms was necessary. The search terms were tested in earlier research [43] which confirmed their suitability for capturing discussions on the two technologies in an inclusive manner.

available from the authors upon request. The screening of the material with the search terms resulted in 243 discussion threads for the analysis.

We used these data in three ways: we conducted Social Network Analysis of discussion networks to understand the network building aspect of SNM, and analysed framing in the posts through quantitative and qualitative coding to understand the content and convergence of expectations and visions related to biogas and ground-source heat pumps.

There are ethical concerns with online and internet data, even when using publicly available text data like ours. The Association for Internet Research ethics guidelines suggest a case-based consideration of potential vulnerability and harm [42], and we follow their recommendations. We have de-identified the data set, but due to the fact that the original data are still publicly available on Facebook, the data are not truly anonymous. However, the topics of the discussions do not concern vulnerable communities, and potential harm to any participant from identification should be minimal. Also the rules of this group emphasize that the discussions are publicly available to non-members, so privacy expectations should be limited.

3.2. Quantitative and qualitative content analysis

First, all the threads were quantitatively coded to select material for more detailed analyses, and to create an overall understanding of the framing of biogas and ground-source heat pumps in the discussions. The quantitative coding was carried out manually in two steps based on a methodology developed for an earlier study [43]. Based on the opening post of the thread, it was defined whether the main focus was on either or both of the technologies or other issues such as energy policy more generally. In unclear cases, any external content linked to the post was also checked, as sometimes the opening post was a rather curt request for others to comment on the linked content.

The quantitative coding was continued focusing on threads with biogas or/and ground-source heat pumps as the main focus of the opening post (n = 165), including the first maximum 20 first-level comments of each thread. By first-level comment, we mean the comments written in reply to the opening post, excluding comments addressing previous comments. This was a methodological choice made as the focus of the analysis was more on the content rather than the flow of the discussion, and after reading the data it turned out impossible to verify whether a discussant had meant to comment on the previous comment or the opening post. The mean length of the discussion threads was 19 comments and the median was 10, so the threshold was set at the first 20 comments in order to cover most of the content.

The posts were coded for their temporal orientation (focus on past, present or future) to determine the share of posts that could be related to future expectations or visions. The level of agreement among the posts was also assessed by coding them for the tone of the post (positive, neutral or negative stance towards the technologies) and the spatial focus (local, regional/sub-national, national or international). Because networking is theorized to support cumulative learning based on e.g. scientific evidence [23] and the goals of the New Energy Policy group also include the dissemination of research results, we were interested in the type of material shared in the posts to back up arguments or to prompt discussions. Hence, we coded the sources of any external content linked to the posts.

We also applied action framing following studies on social mobilization [44] to discern whether the discussions were mainly analytic/prognostic/motivational in their orientation (vis-à-vis the opposing tendencies of niche discussants to focus on pragmatic aspects [36] and of the New Energy Policy Group to stimulate critical discussion) and the share of posts articulating the niche barriers. Four categories were applied: 1) diagnostic, i.e. a problem is identified by describing why an issue is a problem, what the consequences are or who or what is to blame for the problem; 2) prognostic, i.e. the articulation of a proposed solution to the problem or the strategies for carrying out planned solutions; 3) motivational, i.e. moral and motivational reasons are presented regarding why someone should be concerned about the problem and take action on it or ignore it; 4) action framing not applicable to describe the post; a residual category for unclear cases that could not be unambiguously coded in categories 1-3.

A close qualitative reading was applied to a subset of the discussion threads for an in-depth analysis of the articulation of expectations and visions related to the case technologies. We selected threads with biogas or ground-source heat pumps as the main focus, in which the opening post had been coded prognostic (solution-orientated) or diagnostic (what stands in the way of the solutions) and it had a future orientation (n = 47). The entire threads were included i.e. not limiting the analysis to the first 20 comments like in the quantitative coding. Inductive thematic analysis [45] was applied using the Nvivo software [46] to uncover salient framings related to the expectations on where the technologies were going and what their role in the future energy regimes would be, and on the required changes in the socio-technological regime for an accelerated diffusion of the niche technologies.

3.3. Social network analysis

The discussion threads with biogas or heat pumps as the main focus were included in Social Network Analysis to investigate the social networking component of SNM. The entire threads were included, i.e. the opening post and all comments. The network nodes were the participants (discussants) and the links between them were shared discussions: each pair of participants was linked by the number of discussions both posted in. Thus, each link or edge was a weighted, symmetrical link defined as the number of discussions both participated in. The maximum weight was 20. Each node (participant) was coded as participating in mostly biogas discussions, mostly heat pump discussions, or both – the threshold was set so that if the participant posted at least 70% of his/her messages in threads focusing on a particular technology, he/she was coded as focusing on that technology.

Social Network Analysis is an umbrella term for a variety of descriptive, visualization and modelling techniques for network data. Our goal was to connect the theoretical SNM framework to the analysis, and thus we deployed those network metrics that have been used to explore the networking and learning processes in Strategic Niche Management, while adding a few more that speak to the theoretical perspective.

We used the following metrics in our analysis: network density is the number of present ties out of all possible ties. The underlying assumption is that if a network consists of actors that are well-interconnected, this implies that knowledge flows rapidly among them [23].It was previously used by Caniëls & Romijn [23] and van der Valk et al. [26] to measure cohesiveness, while Lopolito et al. [25] used it with specific measures of network knowledge flows and network sharing relations to represent different theoretical concepts. Network centralisation is the ratio of variance in individual degree (number of links) to maximum possible variance (a theoretical maximally centralized network), and has been used as a measure of power with directed network ties [25], while van der Valk et al. [26] see two sides to it, a robust network with a hub-like structure, as well as a directly centralized structure. Transitivity or the clustering coefficient is the probability that those nodes that are linked to one node are linked as well, and has been used to measure the presence of cohesive subgroups [26] or density in a more complex manner [23]. Average and maximum path length measure how many intermediaries are needed to connect pairs of nodes, and have also been used as measures of network cohesion [26]. Degree centrality is simply the number of links each actor has, ignoring link strength, while Eigenvector centrality scales this by including the centrality of those nodes one is connected to, as well as the strength of the connection. Eigenvector centrality is considered the most appropriate centrality measure for measuring influence-type processes [47].

The network analyses were computed using R, especially the network analysis packages igraph [48] and ggraph [49]. The network figure was organized with a Fruchterman-Reingold [50] algorithm, where links simultaneously act as forces attracting participants who are linked and repulsing those that are not linked.

While we have some idea of the discussants in the group, including the profiles of, for instance, a few prominent politicians, we had no reliable way to assess the authenticity of each profile participating in the discussions on Facebook [cf. 5]. Furthermore, it could not be discerned whether a person was participating in the deliberation as a private person or as a representative of their professional or other background organization. Identifying the participants was also limited by the personal data regulation and the ethical guidelines which directed us to treat the research subjects anonymously in our data (see 3.1 above). Therefore, we did not attempt to systematically categorize the participants to analyse, for instance, the type of actors participating in the discussions, but rather focused on describing the networks formed around the discussions and their content in light of the SNM theory.

4. Results

4.1. Social network analysis

There were 295 participants in the discussion threads, who posted a mean of 10.6 messages in the threads, with a minimum of 1 and maximum of 470. 170 of the participants focused on heat pumps, 86 on biogas, and 39 on both. The number of participants in the discussions represented about 7% of the nearly 4500 members of the entire New Energy Policy group shortly after the data extraction for this study[3]. The initiation of the discussions on biogas and ground-source heat pumps was highly skewed in distribution: three participants initiated almost 60% of all threads, and there were only 15 participants who initiated more than one discussion. In Fig. 2, the size of the node is the number of discussions initiated (the number of opening posts).

Fig. 2 shows the discussion network. The figure gives rise to at least three relevant observations: 1) the starting of conversations is highly centralized, especially with regard to heat pump discussions. Three participants initiated more than 10 discussions, and they are thus also the most central nodes in the overall network. 2) The rest of the network is mostly small subgroups focusing on particular technologies. They mainly consist of participants who never initiated any discussions and participated only in a handful of them, often on a fairly specific issue. 3) The distribution of starting discussions is somewhat more evenly distributed for biogas discussions. Eight participants started at least two discussion threads on biogas issues.

The network density was 0.10, meaning 10% of all possible links were present. Our network is much denser than the knowledge flow network of Lopolito et al. [25] (density 0.01), somewhat denser than the Jatropha network of Caniëls and Romijn [23] (density 0.07), but much less dense than the innovation networks of van der Valk et al. [26] (densities of 0.40 and 0.35). These are not directly comparable, as even though the measure is normalized, network size affects it, and the links are very different, but a comparison should highlight how niches vary: sometimes, they are built around single focal points who lead the network (and thus have low densities), sometimes the participants use the network for multiple goals, and thus more central actors and higher densities emerge.

The centralization index of our network is 0.60. This is at the top of the range for other networks (0.52 and 0.43 for van der Valk et al. [26] and between 0.19 and 0.46 for Hermans et al. [24]). Again, the different sizes make the networks not directly comparable, but it does reveal how our network is fairly centralized around a small number of participants.

[3] 4454 members on 28th April 2017

The clustering coefficient is 0.40, almost exactly the same as Caniëls and Romijn [23], 0.397, but less than van der Valk et al. [26], 0.86 and 0.82. The average path length is 2.02 (compared to 1.65 and 1.74 in van der Valk et al. [26]) and maximum path length is 4 (compared to 2 and 3 in van der Valk et al. [26]). In our network, the small subgroups that emerge are not particularly exclusive but the overall network has a large number of actors who bridge the subgroups.

Fig. 1 shows the two centrality distributions: degree centrality is very left-skewed, showing a small number of very active participants. Looking at Eigenvector centrality, the effect is even stronger: not only is there a cluster of very active participants, but they tend to interact with other active participants.

4.2. Quantitative content analysis

The quantitative coding revealed extensive alignment as regards how the case technologies were framed in the posts with the main focus identified as biogas ($n = 299$) or ground-source heat pumps ($n = 389$) (Fig. 3). There was a strong focus on the present-day situation, and posts that could be considered to reflect expectations and visions by having a future orientation constituted only 11% of the posts focusing on biogas and 18% of the posts on heat pumps. Overwhelmingly, the two technologies were presented in a positive light. The posts frequently highlighted them as a solution in the energy transition (prognostic framing) and discussed the barriers for their wider diffusion (diagnostic framing), while few posts intended to stimulate action (motivational framing). Local and national foci dominated the spatial orientation of the posts.

The posts that had a link to external content ($n = 170$) were mostly opening posts and intended to inform or prompt discussion on a specific aspect or statement presented in the linked content. The majority of the shared content consisted of articles in professional magazines with a technological or business focus, or in the mass media, i.e. digital content of national-level newspapers or the Finnish national broadcasting company. Scientific articles were hardly mentioned (two heat pump-focused posts; none on biogas). Also the number of links to blogs and opinion pieces was low (Fig. 3).

4.3. Qualitative content analysis

4.3.1. Biogas

The role of biogas was predominantly represented as that of a complementary and flexible energy source which could be used to fill in some gaps in the current and future renewable energy system. Though different estimates of national-level biogas production potential were put forth, it was doubted whether the entire need for gas could be met with biogas alone. Most frequently, biogas was discussed as a transport fuel, the key questions being: 1) whether it made sense to invest in biogas-fuelled vehicles with the advent of electric vehicles; 2) whether it was better to use biogas as a transport fuel or in the production of electricity. The use of biogas in heating was not discussed, even though out of the 698 GWh energy produced with biogas in 2017, 520 GWh was used for heating and 178 GWh for electricity generation [51].

Considering the current relatively high prices of electric cars, which most discussants did not expect to come down in the near future, biogas-fuelled cars were seen as an excellent alternative to diesel and gasoline-fuelled cars. The discussions often concluded that biogas-fuelled and electric vehicles were complementary rather than alternative. Both were considered necessary to implement the energy transition. A group of politicians joined the discussion by presenting a vision of the future energy system which included the goal of 300,000 electric and biogas cars on the Finnish roads by 2030 (which in 2017 would have constituted about 9% of all registered cars in Finland [52]). Untapped potential for biogas-fuelled vehicles was also noted in the public transport sector, especially concerning city buses.

A number of obstacles and required changes were identified in the

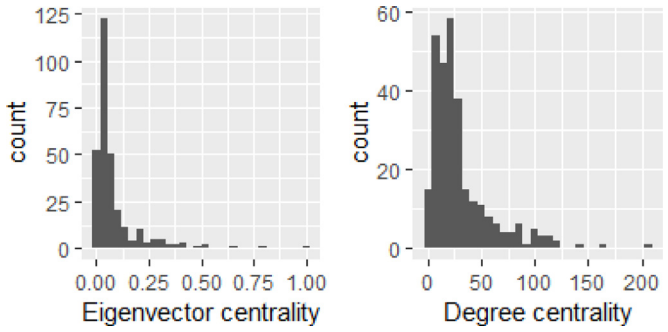

Fig. 1. Distribution of centrality measures in the network.

management or rural policy rather than energy policy. In the rural areas, biogas production could be the basis of new products (fertilizers, transport fuel, electricity) of farms struggling to survive in the globalized market system. Economic instruments to support such development were proposed, including feed-in tariffs for farm-level biogas plants, investment support for the production facilities of biogas, and removing subsidies for oil-fuelled farm machinery. However, the image of biogas as a predominantly rural issue was also suggested to work against the scaling up of the technology to the level required to support the energy transition. In general, the stagnated attitudes of decision makers towards niche technologies and the perceived favouring of established energy actors were critiqued.

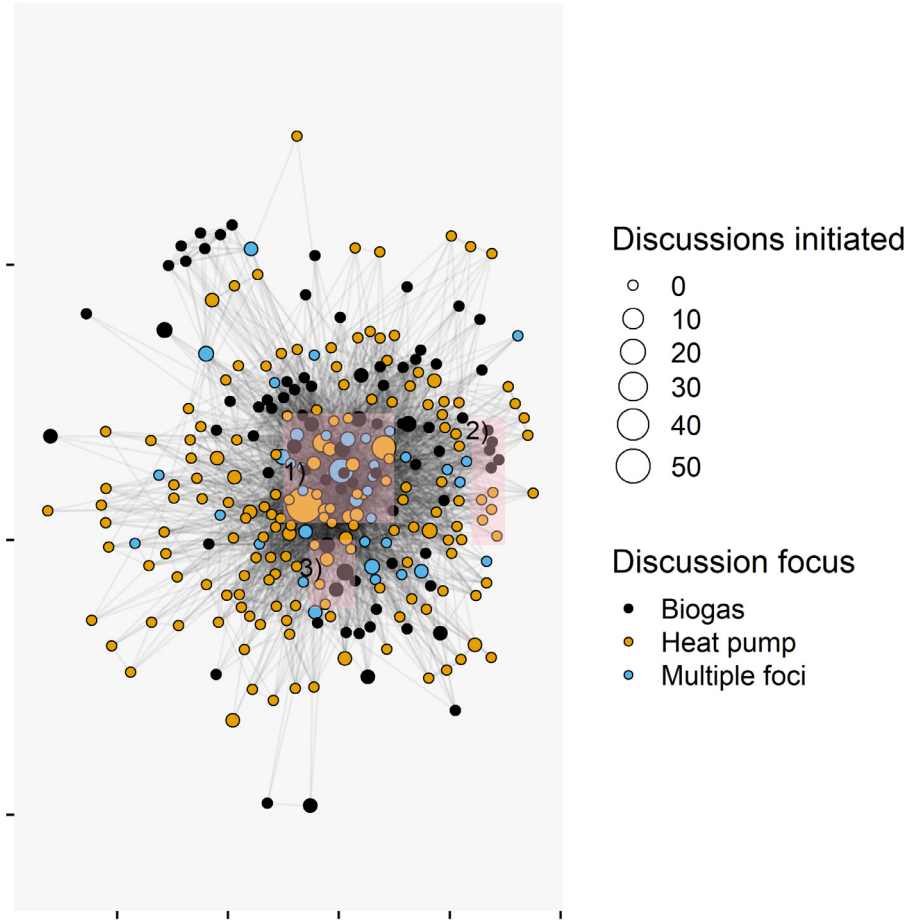

Fig. 2. Discussion networks on biogas and ground-source heat pumps. Nodes (circles) are individual discussants and the lines between the nodes represent discussions. The key observations (1-3) are explained in the text. Note: the image is cropped so that 11 of the most peripheral participants are not shown.

discussions to support the vision of biogas as a complementary transport fuel. The sparse biogas refuelling network was among the challenges for scaling up the adoption of biogas vehicles. Further increasing the taxation of oil was called for, while the proposed economic instruments to support biogas-fuelled transport included incentives to obtain new biogas cars, support for the conversion of combustion engines for biogas, and fixed-term tax exemptions for owners of biogas vehicles. Tax incentives could also be used to encourage service stations to invest in biogas refuelling facilities. At the same time, it was speculated that the trust of consumers in taxation-related instruments was weak because the regulation could be changed in the short term, potentially reducing the willingness of households to make investments in new biogas cars.

It was also questioned whether biogas was an issue of waste

4.3.2. Ground-source heat pumps

Ground-source heat pumps are typically applied in the heating of detached and semi-detached houses, which explains the large portion of posts with a local orientation in the quantitative coding (Fig. 3). In the discussions, it was envisioned that a significant part of heating could be provided with ground-source heat pumps in the future. Production and installations were predicted to increase in the near future. The positive future visions of ground-source heat pumps in the renewable energy mix, salient especially in the opening posts, are partly explained by the activity of person(s) representing The Finnish Heat Pump Association (SULPU) in the discussions. The posts highlighted especially the economic viability and competitiveness of heat pumps compared to oil-based or direct electric heating. Positive expectations concerning growth and employment were also associated with the domestic heat

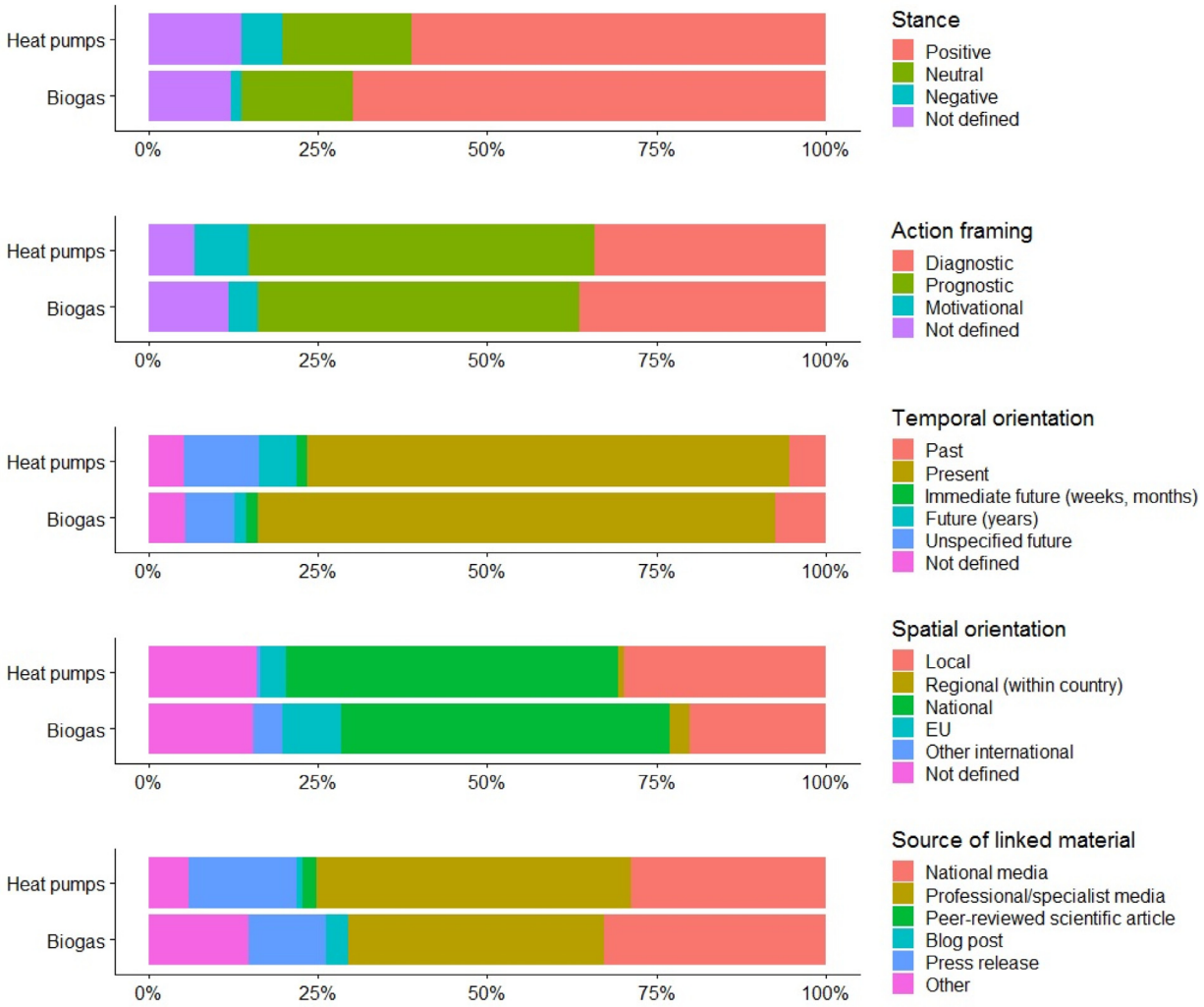

Fig. 3. Distribution of framing in the posts focusing on biogas (n = 299) or ground-source heat pumps (n = 389) according to the quantitative coding.

pump technology replacing imported fuels. The active role of individual energy consumers was emphasized.

Heating is a key issue in Finland, with long winter months and occasional cold periods during which energy consumption peaks. Heat pumps use electricity, contributing to the consumption peaks during freezing temperatures, which was expressed as a counter-argument to the positive future visions on ground-source heat pumps. Different ways to address the challenge were deliberated in the discussions, including heat storage, smart systems that regulate heating according to use (e.g. adjusting heating to lower temperatures when nobody is at home and increasing heating at night when electricity is cheaper), complementary heating with e.g. wood, and generally decreasing electricity consumption as a lifestyle adjustment. Concerns about the impact of heat pumps on electricity consumption were also downplayed by the heat pump enthusiasts who argued that the balance was squarely positive since the ground-source heat pumps usually replaced direct electric heating.

The future of centralized vs. distributed energy systems was touched upon in discussions that concerned the increase of individual ground-source heating installations at the cost of decreased participation in district heating systems. It was lamented that the district heating infrastructure would be rendered under-used, though it was also argued that the infrastructure was in part outdated anyway and should "die out". The pricing of district heating compared to ground-source heat pumps was debated, as well as the ways to make district heating more sustainable, including the development of large-scale ground-source heat pumps.

Satisfaction with plans to increase the taxation of oil was expressed, seen to work in the advantage of the diffusion of ground-source heat pumps. Otherwise, references to taxation-based or other economic instruments to support the technology were fragmented in the discussions, and attempts to stimulate energy policy-focused debates were often quickly narrowed down to a discussion on technical details or personal experiences. A noteworthy exception was a discussion in which it was suggested that ground-source heat pumps have received little explicit attention in the national policies and strategies because of a misconceived expectation of decision makers and bureaucrats that the investments in the field will develop anyway, without public interventions or support.

5. Discussion and conclusions

Public debate in various arenas may influence the development of niche technologies, contributing to energy transitions. This study has explored the features of Strategic Niche Management in a novel setting: an open social media platform (a Facebook group). Social Network Analysis was applied to investigate the discussion networks concerning two renewable energy technologies, biogas and ground-source heat pumps, and quantitative and qualitative content analysis of the posts in the discussion threads examined the articulation and convergence of expectations and visions regarding the two technologies.

Despite being broader than the previously studied offline inter-organizational or interpersonal professional networks for niche

technologies [23–25], the Facebook networks of biogas and heat pump discussants represented a fairly small fraction of the total number of members in the studied New Energy Policy group. Though it must be noted that merely observing others is far more common than posting on social media [53], this might reflect the specificity of the topics and the tendency of the discussions to frequently draw from particular local level examples, as revealed by the quantitative and qualitative content analysis. The inclination to narrow the debate down to technical details resonates with the finding of Hyysalo et al. [36] that niche-level discussants focus on pragmatic technological and economic issues, which may function to deter more generalist energy policy discussants from joining in. This, in turn, may forestall wider social learning and building of connections between niche and regime levels.

The networks were also highly centralized around a few active discussants, and especially the initiation of the discussions relied on a handful of participants. This begs the question of how much the social media networking for biogas and ground-source heat pumps is dependent on a few active individuals, and what would happen if they ceased to be active? Would their places be filled, or would the discussion on these two technologies die out? In this sense, the high centralization is likely to be a weakness of the network from the perspective of innovation diffusion processes or from the perspective of social media debates contributing to energy transitions. Furthermore, the risk for significantly skewed framings and topic selection increases as personal interests and attitudes of just a few individuals dominate the initiation of the discussion, partly regardless of the diversity of the follow-up debate.

It is also possible that the discussion networks on biogas and ground-source heat pumps in the group actually function to "get the best of both worlds" for SNM. The expansive networks formed around a few active members may be able draw from a larger pool of ideas by more sporadic discussants. They represent "weak ties" [30] that may be able to bring in novelty and diversity. At the same time, there are smaller, more tightly-knit clusters in the networks that may provide enough reinforcement to direct the participants' attention and learning towards certain aspects, overcoming the diluting effects of too wide and diverse networks [22] − which could constitute a pitfall of open social media platforms in terms of SNM.

The quantitative content analysis of the posts focusing on biogas and ground-source heat pumps paints a highly convergent picture of the framing of these two technologies as preferable future energy options. However, the share of posts with a discernible future orientation was low. This suggests that the articulation of expectations and future visions related to these technologies was not an eminent feature of the discussions, despite the general aim of the New Energy Policy Facebook group to stimulate forward-looking debates. Likewise, in spite of the original affiliation of the group with a political campaign, motivational framing (that intends to mobilize action) was rare among the posts focusing on these two technologies. Instead, the analysis indicated features that may support learning as an SNM process: the focus was on debating the present-day situation concerning the two technologies as solutions in the energy transition (prognostic framing) and the obstacles for their wider adoption (diagnostic framing), while drawing from experiences at the local, regional (sub-national) and national level.

It could be expected that the applicability of state-of-the-art research results would be at the core of the discussions in the group because of the importance of scientific information on new technologies for energy transitions. Yet the views expressed in the discussions were mostly backed by or commented on content produced by the mass media or professional media, instead of scientific publications. Considering the low number of active discussion starters and that external content was typically linked to the opening post of the discussion thread, this might suggest a high reliance on certain sources of information among the dominant discussants. It might also stem from a need to collectively reflect on how the niche technologies are portrayed in the popular media, which may have an important effect on socio-technological transitions [54,55]. Moreover, research results can also enter the debate indirectly through press releases routinely used as sources by journalists, i.e. intermediated by the popular media, though we did not peruse the linked content at such level of detail.

The overwhelmingly positive framing of especially ground-source heat pumps in the Facebook discussions is in line with what has been demonstrated elsewhere. According to a survey [56], ground-source heat pumps were viewed as the best and the cheapest energy form by Finns, and also one of the least environmentally harmful forms of energy. When asked which energy sources should be used more in the future, ground-source heat pumps ranked the second highest, right after solar energy [56]. Earlier research has shown that also the newspaper debate on biogas in Finland is characterized by very positive tones [43,57] − contrary to other countries, such as Germany, where debates highlight the harmful environmental effects and risks of large-scale biogas production [58]. The positive views may contribute to the further recruitment of constituencies for these technologies and consolidate their framings as sustainable alternatives, which may help to attract political attention and financial support.

Despite the considerable alignment in the framing of the case technologies based on the quantitative coding, the qualitative analysis exposed important inner tensions and contradictions that somewhat reduced the cohesion of the future expectations deliberated in the discussions. This was reflected, for instance, in the debates on electric vs. biogas vehicles, the effect of heat pumps on electricity consumption, and the roles of heat pumps vs. district heating systems. The hybrid-community nature of the Facebook group probably affects this; differing and diverse viewpoints are more likely to be presented in an open social media group than in communities and networks that consist of more homogenous actors, such as the previously studied demonstration projects directly involved in developing niche innovations [24,25]. From the perspective of SNM, the counter-argumentation in the debates could present an opportunity: for reflexive learning through the testing of arguments that support the niche technologies when encountering critique, and for the iterative development of expectations and visions that assimilate valid critical viewpoints.

The qualitative analysis also revealed that the emphasis in the Facebook discussions was on slightly different topics compared to the treatment of biogas and ground-source heat pumps in other arenas of communication and interaction [43,59]. For instance, the most significant use of biogas at the time of the data collection, i.e. heating, was not discussed at all, but the most salient theme was its potential and role in transport. Furthermore, the press debate tends to focus on the production of biogas [43] while in the Facebook discussions, consumers and energy demand were emphasized. This could reflect an inclination to highlight novel consumer-oriented openings with potential to widen the consumer base beyond the established uses of the technologies. Interactive social media has been particularly employed with the aim of increasing the engagement of consumers in energy transitions [9]. Demonstrating wider potential for benefits of the technologies than is usually perceived is also likely to be important when engaging decision makers and when linking to timely political debates, such as how to achieve a sustainability transformation in the transport sector. In the same vain, studying energy perceptions on social media may be used to devise strategies that help bridge gaps in and expand the energy market in concert with social advocacy and policy priorities [5].

A caveat of our research is that while we have limited knowledge of the participants in the discussion networks and their motives in relation to biogas, ground-source heat pumps and energy transitions, much of the interpretation of the results remains speculative. The de-identification of the discussants in the data was a deliberate choice based on ethical research guidelines and the methodological challenges of convincingly assessing online identities [5]. However, the results offer some interesting first insights into the workings of Strategic Niche Management in open online communities focused on renewable energy issues.

The results suggest that within broad online debates on energy transitions, more focused niche networks emerge. Such spaces can combine the strengths of expansive and diverse networks, beneficial for the spread of ideas, with tighter clusters or smaller sub-groups conducive for learning. High centralization of the network around a few active individuals, however, poses a potential weakness and may limit the scope of the debate and subsequently the recruitment of new relevant participants, with their ideas and resources, in the development of the niches and influencing the wider socio-technical regimes. How the niche interacts with the broader debates on energy policy will affect these developments, and further analyses of SNM and social media should focus on niche-regime interactions. Expanding the analyses to cover different established and emerging technologies would allow comparisons between them, and network analyses of the overall discussion networks on energy policy, beyond discussions focused on particular technologies, would allow comparisons between within-niche and niche-regime interactions.

Though the articulation of expectations and visions was not a predominant feature of the studied online discussions, clear salient themes and framings were detected in the threads that were future-orientated. Their foci were slightly different compared to debates elsewhere, especially concerning biogas, suggesting a different audience that may be specific for online debates, including consumers and politicians. The overall emphasis of the debate was on analysing the current situation, drawing from detailed examples and experiences. This may be conducive for learning which is often stressed as a particularly important component of Strategic Niche Management [22] and ultimately directs future action. Future research based on social media data could target learning more directly, for instance by applying longitudinal network analysis methods that account for how the network is built in tracking the spread of ideas and learning. Such analyses could provide more conclusive evidence on whether or not open online platforms support the key tenets of Strategic Niche Management.

Declaration of Competing Interest

None.

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